

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference RD25712	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below	
International application No. PCT/US 98/ 19021	International filing date (day/month/year) 14/09/1998	(Earliest) Priority Date (day/month/year) 12/09/1997
Applicant GENERAL ELECTRIC COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of **3** sheets.
☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ **Certain claims were found unsearchable** (see Box I).
2. ☐ **Unity of invention is lacking** (see Box II).
3. ☐ The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
- ☐ filed with the international application.
☐ furnished by the applicant separately from the international application.
☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.

☐ Transcribed by this Authority

4. With regard to the **title**, ☐ the text is approved as submitted by the applicant
☒ the text has been established by this Authority to read as follows:

METHOD AND APPARATUS FOR PRODUCING DIRECTIONALLY SOLIDIFIED CASTINGS

5. With regard to the **abstract**, ☒ the text is approved as submitted by the applicant
☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

Figure No. **1**

- ☒ as suggested by the applicant.
☐ because the applicant failed to suggest a figure.
☐ because this figure better characterizes the invention.

☐ None of the figures.



INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 98/19021

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B22D27/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B22D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 168 916 A (J.-C. DORIATH ET AL.) 8 December 1992 see claim 1: figures 1-6 & FR 2 604 378 A cited in the application ---	1,9
A	US 3 680 625 A (F. J. HEIN ET AL.) 1 August 1972 cited in the application see claim 1: figures 1-3 ---	1
A	US 4 804 311 A (N. P. ANDERSON ET AL.) 14 February 1989 cited in the application see claim 1: figures 1-13 ---	1
-/--		

☒ Further documents are listed in the continuation of box C☒ Patent family members are listed in annex

Special categories of cited documents

- A document defining the general state of the art which is not considered to be of particular relevance
- E earlier document but published on or after the international filing date
- L document which may throw doubts on priority (claim(s)) or which is cited to establish the publication date of another citation or other special reason (as specified)
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- X document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

30 November 1998

Date of mailing of the international search report

04/12/1998

Name and mailing address of the ISA

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NL - 2280 HV Rijswijk
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication where appropriate of the relevant passages	Relevant to claim No
A	US 4 412 577 A (R. W. SALKELD ET AL.) 1 November 1983 cited in the application see claim 1: figures 1-8 ---	1
A	US 3 763 926 A (J. G. TSCHINKEL ET AL.) 9 October 1973 cited in the application see claim 1: figures 1-8 ---	1
A	US 3 915 761 A (J. G. TSCHINKEL ET AL.) 28 October 1975 cited in the application see claim 1: figures 1-8 ---	1
A	SOVIET PATENTS ABSTRACTS Section Ch. Week 9503 Derwent Publications Ltd., London, GB: Class M22, AN 95-020454 XP002085790 & RU 2 010 672 C (AVIAT MATERIALS RES PRODN ASSOC), 15 April 1994 cited in the application see abstract ---	1
A	US 5 197 531 A (F. HUGO ET AL.) 30 March 1993 cited in the application see claim 1: figures 1-9 ---	1
A	US 3 532 155 A (L. I. KANE ET AL.) 6 October 1970 see claims 1.3: figure 2 ---	1.9
A	GB 2 309 405 A (ALD VACUUM TECHNOLOGIES GMBH) 30 July 1997 see claim 1 ---	1.9
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A	EP 0 749 790 A (ABB RESEARCH LTD.) 27 December 1996 see claim 1: figure -----	1.9



INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/19021

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/19021

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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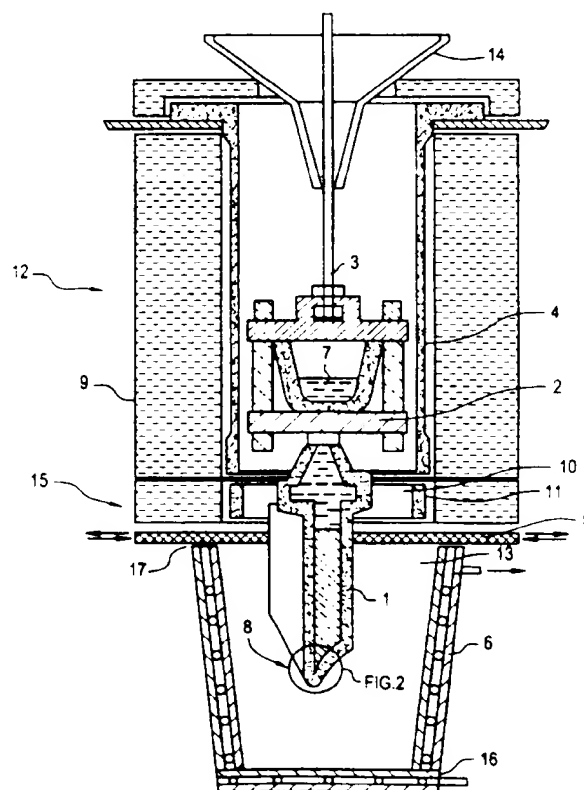
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B22D 27/04		(11) International Publication Number: WO 99/12679
A1		(43) International Publication Date: 18 March 1999 (18.03.99)
(21) International Application Number: PCT/US98/19021		(74) Agents: CHASKIN, Jay, L.; General Electric Company, 3135 Easton Turnpike W3C, Fairfield, CT 06431 (US) et al.
(22) International Filing Date: 14 September 1998 (14.09.98)		(81) Designated States: CA, CN, JP, KR, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
(30) Priority Data: 97115515 12 September 1997 (12.09.97) RU		Published With international search report.
(71) Applicants (for all designated States except US): GENERAL ELECTRIC COMPANY [US/US]; 1 River Road, Schenectady, NY 12345 (US). ALL-RUSSIAN SCIENTIFIC-RESEARCH INSTITUTE OF AVIATION MATERIALS [RU/RU]; 17 Radio Street, Moscow, 107005 (RU).		
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(54) Title: METHOD AND APPARATUS FOR PRODUCING DIRECTIONALLY SOLIDIFIED CASTINGS

(57) Abstract

The present invention relates to an apparatus for metal casting and can be used in producing castings with directional and single crystal structure. The apparatus comprises a vacuum chamber (12) inside which there is disposed an induction melting furnace (15), a mold preheating furnace (9) with a ceramic mold (1), and a water-cooled tank (6) being shaped as a truncated cone having a bottom portion (16) and an upper portion (17) which is opened towards a heating zone (10). The heating zone (10) and the cooling zone (13) are separated by a baffle (5) articulating in a horizontal plane and consisting of segments or sectors. The apparatus allows the production of high quality castings having the directional and single crystal structure including the large sized castings by both the method of radiation cooling and the method of liquid metal cooling. Said invention gives the possibility to use successively the disclosed apparatus as a mold catch basin in the event of mold breakage and to increase the reliability and economic profitability of the apparatus' performance.



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METHOD AND APPARATUS FOR PRODUCING DIRECTIONALLY SOLIDIFIED CASTINGS

FIELD OF THE INVENTION

5

The present invention relates to metal casting and can be used in producing castings with directional and single crystal structure. In particular the invention relates to a metal casting apparatus with a water-cooled tank having a truncated cone shape.

BACKGROUND OF THE INVENTION

10

An apparatus for directional solidification generally comprises a vacuum chamber inside which there are disposed a mold heating zone, a baffle system, a water-cooled chill plate usually made of copper, an induction furnace, and a thermocouple system that automatically controls and maintains the temperature in a cooling zone and in a heating zone within the furnace. Such features are disclosed in U.S. Patent Nos 3680625, 4804311, and 4412577.

15

Also known in the art is an apparatus for directional solidification, in which the cooling zone is a liquid cooling bath with a material that melts easily to serve the role of the cooling medium. The liquid metal bath is disclosed in U.S. Patent Nos 3763926 and 3915761, and Russian Federation Patent No 2010672.

20

Apparatuses in which both types of the above mentioned assemblies are combined (i.e., the copper chill plate and the liquid metal cooling bath) are also known. But those apparatuses comprise two actuators for vertical transportation of a mold with a metal casting. These actuators are disposed above and beneath the vacuum chamber housing. For that reason the dimensions of the apparatuses are enlarged and the service of the installations become complicated

25

- 2 -

while the reliability of the apparatuses is decreased (see U.S. Patent 5197531, and the publication Singer R.F. "Directional and Single Crystal Solidification Using LMC").

The closest prior art to the present invention is an
5 apparatus disclosed in French Patent Application 2604378, being
accepted as a prototype. This prototype apparatus comprises a
vacuum chamber with a heating member inside where there is
disposed a ceramic mold fixed on a water-cooled metallic plate which
10 is moved up and down with the help of a rod and of an actuator for
vertical transportation. A horizontal baffle separates a heating zone
and a cooling zone. In the cooling zone, concentrically with the chill
plate, there is disposed an additional circular water-cooled cavity with
the inner diameter exceeding the mold's maximal size. Below the
15 cavity there is disposed a container which is utilized for capturing the
poured casting metal in the event of mold breakage.

The above apparatuses, including the prototype, can
function only when they comprise a crystallizer. It is impossible to use
such installation for directional solidification processing with a liquid
metal coolant and it is difficult to utilize the expensive alloys used in
20 directional solidification castings in the event of mold breakage. Thus
there is a need for a casting apparatus that provides a means that
efficiently cools the molten cast alloy while protecting the equipment
from damage in the event that the ceramic mold breaks while
containing the molten cast alloy material.

25 SUMMARY OF THE INVENTION

The technical aim of this invention is to produce castings
having the directional and single crystal structure by the method of
radiation cooling without using the above-mentioned crystallizer.
Another aim of the invention is to be able to reconstruct easily the
30 invented apparatus for both radiation crystallization processing and
liquid metal cooling crystallization processing. The inventive apparatus

also increases the reliability and economic profit due to the apparatus' performance.

To achieve said aim the inventive apparatus comprises a vacuum chamber inside which there is disposed an induction melting
5 furnace, a mold preheating furnace with a ceramic mold, a drive assembly for mold transportation and a water-cooled tank. The drive assembly comprises a rod on which the mold is fixed with the help of a hanger and a regulating actuator for vertical movement being
10 positioned above the vacuum chamber. The water-cooled tank is shaped as a truncated cone. Its upper portion is opened towards the heating zone, and its bottom portion has a smaller base than the upper portion. A baffle separates the heating zone inside the induction furnace from the cooling zone; said baffle moves in a horizontal plane and closely adjoins the mold during the solidification process. It
15 consists of the segments or sectors (not less than 2 from each side).

BRIEF DESCRIPTION OF THE DRAWING

Figs.1 and 2 show a schematic drawing of the apparatus where 1 is the ceramic mold, 2 is the hanger to fix the mold to the drive assembly, 3 is the rod, 4 is the heater of the mold preheating furnace,
20 5 is the heat baffle, 6 is the water cooled tank, 7 is the molten superalloy, and 8 is the starting zone with a seed.

DESCRIPTION OF THE INVENTION

The apparatus performs as follows: the mold (1) is disposed on the hanger (2) and is fixed on the movable rod (3). The
25 hanger (2), the movable rod (3), and the regulating actuator comprise the drive assembly (14). The mold (1) is placed into the mold preheater furnace (9) with the help of the actuator while regulating the mold position relative to the heater (4). The heat baffle (5) is disposed under the heating zone (10). The top butt end of the water-cooled tank
30 (6) adjoins the baffle's (5) lower surface and is positioned coaxially with

- 4 -

the heater (4) and (11). The vacuum chamber (12) is evacuated to 1×10^{-3} mm m.c. The mold preheating furnace (9) is switched on. Upon reaching the mold temperature of 100-150 °C higher than the liquidus temperature of the alloy being cast, the induction furnace's heater (11) is switched on, the alloy (7) being cast melts and is poured into the heated ceramic mold at the predetermined temperature. After that, the actuator for vertical transportation lowers the mold from the heating zone (10) into the cooling zone (13) at the required rate. Solidification of the molten cast alloy occurs by radiation onto the cold walls of the water-cooled tank. Due to this fact it becomes possible to produce large sized castings with directional and single crystal microstructure. Large size castings can include blades, nozzles, buckets, airfoils, and the like, that are used both in aircraft and land-based turbine engines. The castings are often greater than 30 inches in overall height.

Once the mold with the casting alloy has been lowered along its complete height into the cooling zone, the heater (4 and 11) is switched off. When the temperature is decreased to 300-400 °C, the mold with the solidified casting alloy is extracted from the installation which has been previously decompressed. Then the process is repeated for the next mold.

In another aspect of this invention, in order to produce blades having single crystal structure with desired orientation, a single crystal seed with proper orientation is positioned into the top of the starting zone (8) of the ceramic mold before it is disposed in the vacuum chamber. Then the mold position is strictly fixed relative to the heater. In such event the seed and the solidified portion of the starting zone serve as a cooling medium, and further solidification of the melt is caused by radiation cooling in the water-cooled tank as stated above. The use of the water-cooled tank instead of a chill plate allows the same or better working efficiency of said tank than that of a chill plate or of the prototype circular water-cooled cavity. At the same time the water-cooled tank of this invention does not require the use of a complex drive assembly with airtight seals.

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As stated above, the heat baffle (5) is used for raising the axial temperature gradient at the solidification front. Said baffle moves in a horizontal plane, closely adjoins the ceramic mold according to its geometry during the solidification process and consists of the

5 segments or sectors (not less than 2 from each side).

In the inventive apparatus the water-cooled tank may be made of stainless steel and contain a double layer wall surrounding the perimeter of the tank. A vacuum atmosphere is created in the tank to further aid in the cooling of the cast parts. The tank may also

10 effectively function as a mold catch basin in the event of mold breakage, and the expensive, poured casting alloy may be easily removed from the tapered tank and be remelted.

The apparatus of this invention allows one to produce high quality castings having the directional and single crystal structure,

15 including the large sized castings used in the land based turbine industry, by the method of radiation cooling without using the crystallizers of the prior art. The invention also gives the possibility to reconstruct easily the disclosed apparatus for liquid metal cooling crystallization processing, to use successively the invented water-

20 cooled tank as a mold catch basin in the event of mold breakage, and to increase the reliability and economic profitability of the apparatus' performance.

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What is claimed:

1. An apparatus for producing castings with directional and single crystal structure, comprising a vacuum chamber (12) inside which there is positioned an induction melting furnace (15), mold preheating furnace (9) with a ceramic mold (1), mold transportation
5 drive assembly (14) consisting of a rod (3) and an actuator for vertical movement, and a baffle (5) separating a cooling zone (13) and a heating zone (10); said apparatus being characterized in that the cooling zone (13) means a water-cooled tank (6) having a bottom
10 portion (16) and an upper portion (17) being opened towards the heating zone (10).
2. The apparatus of claim 1 characterized in that the water-cooled tank (6) is shaped as a truncated cone with its bottom portion (16) having a smaller base than the upper portion (17) of the tank (6).
3. The apparatus of claim 1 characterized in that a baffle (5) articulates in a horizontal plane and consists of at least two sectors or segments, closely adjoining the ceramic mold (1) during a solidification process.
4. The apparatus of claim 1 where the drive assembly (14) further comprises a mold hanger (2).
5. The apparatus of claim 1 where said water-cooled tank (6) can be used as a mold catch basin.
6. The apparatus of claim 1 where said mold (1) contains a starter cavity (8) for a crystal having a defined crystal orientation.
7. The apparatus of claim 1 where the water-cooled tank (6) has a double wall.
8. The apparatus of claim 1 where the water-cooled tank (6) is made of stainless steel.

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9. A method of making a directional or single crystal alloy structure comprising the steps: placing a mold (1) in a mold preheating furnace (9) relative to a heater (4) ; heating the mold (1) to a temperature of about 100 to 150 °C above the liquidus temperature of a casting alloy; melting the casting alloy; pouring the molten alloy (7) into the heated mold (1); lowering the mold (1) with the molten alloy at a required rate from a heating zone (10) into a cooling zone (13) comprising a water-cooled tank (6); and solidifying the molten alloy by radiation onto the water-cooled walls of the tank (6).

10. The method of claim 9 where the mold (1) passes through a baffle (5) located between the heating zone (10) and the cooling zone (13).

11. The article made according to the method of claim 9.

12. The article made according to the method of claim 9 having a single crystal structure.

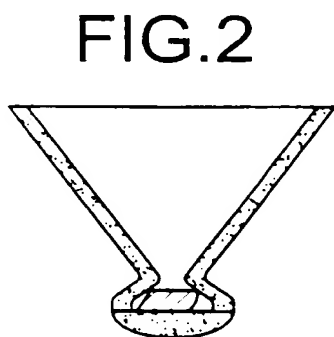
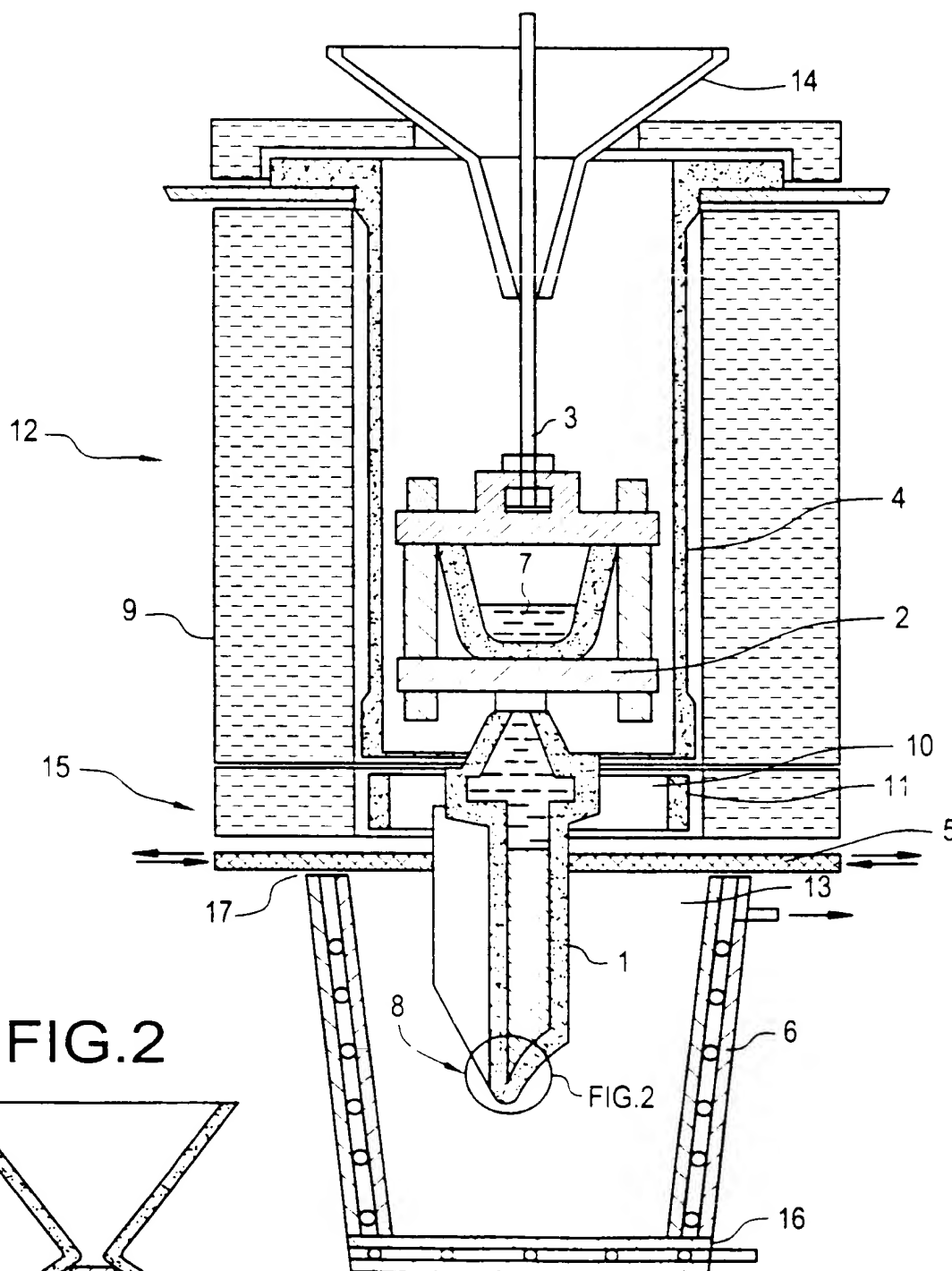
13. The article made according to the method of claim 9 comprising an airfoil.

14. The article according to claim 13 having a length greater than 30 inches.



1 / 1

FIG.1



510 Recd ST/PTO 14 JUN-1999

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 98/19021

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B22D27/04

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B22D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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Special categories of cited documents

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- E: earlier document but published on or after the international filing date
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- X: document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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- Z: document member of the same patent family

Date of the actual completion of the international search

30 November 1998

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04/12/1998

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

International Application No.

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C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	SOVIET PATENTS ABSTRACTS Section Ch. Week 9503 Derwent Publications Ltd., London. GB; Class M22. AN 95-020454 XP002085790 & RU 2 010 672 C (AVIAT MATERIALS RES PRODN ASSOC), 15 April 1994 cited in the application see abstract ---	1
A	US 5 197 531 A (F. HUGO ET AL.) 30 March 1993 cited in the application see claim 1; figures 1-9 ---	1
A	US 3 532 155 A (L. I. KANE ET AL.) 6 October 1970 see claims 1,3; figure 2 ---	1,9
A	GB 2 309 405 A (ALD VACUUM TECHNOLOGIES GMBH) 30 July 1997 see claim 1 ---	1,9
A	EP 0 631 832 A (LEYBOLD DURFERRIT GMBH) 4 January 1995 see claim 1; figures 1-3 ---	1,9
A	EP 0 749 790 A (ABB RESEARCH LTD.) 27 December 1996 see claim 1; figure -----	1,9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.

PCT/US 98/19021

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			DE 2926194 C	09-06-1988
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			FR 2152649 A	27-04-1973
			GB 1369270 A	02-10-1974
			JP 48038236 A	05-06-1973
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International Application No

PCT/US 98/19021

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EP 749790 A	27-12-1996	DE 19539770 A	02-01-1997
		EA 960020 A	31-12-1996
		JP 9010919 A	14-01-1997

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

To:
General Electric Company
International Patent Operation
Attn. CHASKIN, J.
3135 Easton Turnpike Mail Drop W3C
Fairfield, Connecticut 06431-0001
UNITED STATES OF AMERICA

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

PCT Rule 44.11

<p>Date of mailing (day/month/year) 04/12/1998</p>	
<p>Applicant's or agent's file reference RD25712</p>	<p>FOR FURTHER ACTION See paragraphs 1 and 4 below</p>
<p>International application No. PCT/US 98/19021</p>	<p>International filing date (day/month/year) 14/09/1998</p>
<p>Applicant GENERAL ELECTRIC COMPANY et al.</p>	

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46).

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No. (+41-22) 740 14 35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ **With regard to the protest** against payment of (any) additional fee(s) under Rule 40(2), the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90b/s 1 and 90b/s 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand for international preliminary examination or a later election within 19 months from the priority date or could not be elected because they are not bound by the demand.

<p>Name and mailing address of the International Searching Authority</p> <p>European Patent Office, P. B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel.: (+31-70) 340-2040, Tx: 31 651 epo nl Fax: (+31-70) 340-3016</p>	<p>Authorized officer</p> <p style="text-align: center;">Chantal Meyer</p>
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NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under Article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.



NOTES TO FORM PCT ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether:

- (i) the claim is unchanged,
- (ii) the claim is cancelled,
- (iii) the claim is new,
- (iv) the claim replaces one or more claims as filed,
- (v) the claim is the result of the division of a claim as filed

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

- 1 [Where originally there were 48 claims and after amendment of some claims there are 51]
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers, claims 30, 33 and 36 unchanged, new claims 49 to 51 added."
- 2 [Where originally there were 15 claims and after amendment of all claims there are 11]
"Claims 1 to 15 replaced by amended claims 1 to 11."
- 3 [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]
"Claims 1 to 6 and 14 unchanged, claims 7 to 13 cancelled, new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled, new claims 15, 16 and 17 added, all other claims unchanged."
- 4 [Where various kinds of amendments are made]
"Claims 1-10 unchanged, claims 11 to 13, 18 and 19 cancelled, claims 14, 15 and 16 replaced by amended claim 14, claim 17 subdivided into amended claims 15, 16 and 17, new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)".

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.



PCT

INTERNATIONAL SEARCH REPORT

PCT Article 18 and Rules 43 and 44

Applicant's or agent's file reference RD25712	FOR FURTHER ACTION see Notification of Transmittal of International Search Report Form PCT/ISA 220 as well as, where applicable, item 5 below	
International application No. PCT/US 98/19021	International filing date (day/month/year) 14/09/1998	Earliest Priority Date (day/month/year) 12/09/1997
Applicant GENERAL ELECTRIC COMPANY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ **Certain claims were found unsearchable** (see Box II).
2. ☐ **Unity of invention is lacking** (see Box III).
3. ☐ The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing.
 - ☐ filed with the international application.
 - ☐ furnished by the applicant separately from the international application.
 - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
 - ☐ Transcribed by this Authority.
4. With regard to the **title**, ☐ the text is approved as submitted by the applicant.
 - ☒ the text has been established by this Authority to read as follows:

METHOD AND APPARATUS FOR PRODUCING DIRECTIONALLY SOLIDIFIED CASTINGS

5. With regard to the **abstract**,
 - ☒ the text is approved as submitted by the applicant.
 - ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.
6. The figure of the **drawings** to be published with the abstract is:
 - Figure No. 1 ☒ as suggested by the applicant. ☐ None of the figures.
 - ☐ because the applicant failed to suggest a figure.
 - ☐ because this figure better characterizes the invention.



INTERNATIONAL SEARCH REPORT

national Application No.

PCT/US 98/19021

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B22D27/04

According to International Patent Classification (IPC) into international classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched: classification system followed by classification symbols
IPC 6 B22D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search: name of data base and, where practical, search terms used

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
----------	--	-----------------------

A	US 5 168 916 A (J.-C. DORIATH ET AL.) 8 December 1992 see claim 1: figures 1-6 & FR 2 604 378 A cited in the application ---	1,9
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A	US 3 680 625 A (F. J. HEIN ET AL.) 1 August 1972 cited in the application see claim 1: figures 1-3 ---	1
---	--	---

A	US 4 804 311 A (N. P. ANDERSON ET AL.) 14 February 1989 cited in the application see claim 1: figures 1-13 ---	1
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-/-

☒ Further documents are listed in the continuation of box C

☒ Patent family members are listed in annex

Special categories of cited documents

- A document defining the general state of the art which is not considered to be of particular relevance
- E earlier document but published on or after the international filing date
- L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- O document referring to an oral disclosure, use, exhibition or other means
- P document published prior to the international filing date but later than the priority date claimed

- * later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- * document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- * document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- * document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

30 November 1998

04/12/1998

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl
Fax: (+31-70) 340-3016

Authorized officer

Sutor, W



INTERNATIONAL SEARCH REPORT

National Application No.

PCT/AUS 98/19021

Continuation: DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Designation of document with indication where appropriate of the relevant passages	Relevant to claim No.
A	US 4 412 577 A (R. W. SALKELD ET AL.) 1 November 1983 cited in the application see claim 1: figures 1-8 ---	1
A	US 3 763 926 A (J. G. TSCHINKEL ET AL.) 9 October 1973 cited in the application see claim 1: figures 1-8 ---	1
A	US 3 915 761 A (J. G. TSCHINKEL ET AL.) 28 October 1975 cited in the application see claim 1: figures 1-8 ---	1
A	SOVIET PATENTS ABSTRACTS Section Ch. Week 9503 Derwent Publications Ltd., London, GB: Class M22, AN 95-020454 XP002085790 & RU 2 010 672 C (AVIAT MATERIALS RES PRODN ASSOC), 15 April 1994 cited in the application see abstract ---	1
A	US 5 197 531 A (F. HUGO ET AL.) 30 March 1993 cited in the application see claim 1: figures 1-9 ---	1
A	US 3 532 155 A (L. I. KANE ET AL.) 6 October 1970 see claims 1.3; figure 2 ---	1.9
A	GB 2 309 405 A (ALD VACUUM TECHNOLOGIES GMBH) 30 July 1997 see claim 1 ---	1.9
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A	EP 0 749 790 A (ABB RESEARCH LTD.) 27 December 1996 see claim 1: figure -----	1.9



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			AT 115020 T	15-12-1994



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			JP 2063995 C	24-06-1996
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US 3532155	A	06-10-1970	NONE	
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			JP 9206918 A	12-08-1997
			US 5778961 A	14-07-1998
EP 631832	A	04-01-1995	NONE	
EP 749790	A	27-12-1996	DE 19539770 A	02-01-1997
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			JP 9010919 A	14-01-1997

